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(21) International Application Number: PCT/GB88/00511 (22) International Filing Date: 29 June 1988 (29.06.88) (31) Priority Application Number: 8715238 (32) Priority Date: 29 June 1987 (29.06.87) (33) Priority Country: GB (71) Applicant (for all designated States except US): QUADRANT BIORESOURCES LIMITED [GB/GB]; Manor Farm, Soulbury, Near Leighton Buzzard, Bedfordshire (GB). (72) Inventor; and (75) Inventor/Applicant (for US only) : ROSER, Bruce, Joseph [AU/GB]; The Old Vicarage, Church Lane, Balsham, Cambridgeshire (GB). (74) Agent: ABLEWHITE, Alan, James; Marks & Clerk, 57-60 Lincoln's Inn Fields, London WC2A 3LS (GB).		(81) Designated States: AU, DK, FI, HU, JP, NO, SU, US. Published <i>With international search report.</i>
(54) Title: FOOD PROCESS (57) Abstract A method of drying a water-containing foodstuff or beverage at a temperature above ambient, is characterised by incorporating trehalose into the foodstuff or beverage which is to be dried.		

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Food Process

The present invention relates to the protection of food against denaturing on being dried at elevated temperatures.

Foodstuffs containing proteins or protein-related materials derived from cell walls, are difficult to preserve by drying at above ambient temperatures while retaining their original quality. For example, whole milk contains a range of proteins including acid precipitable phospho proteins/caseins, immunoglobulins, lactoglobulins and albumin. These proteins tend to be denatured when fresh milk is heated, for example giving rise to the characteristic skin formed on hot milk. Spray drying of milk concentrates degrades these proteins, providing a powdered product which, when reconstituted, does not closely resemble fresh milk. Instead, it has an inferior flavour, it loses its ability to clot with rennin and tends to coagulate in the presence of very hot water.

In the spray drying of milk, concentrates sweetened with sucrose are known to cause even more difficulties as the extra viscosity and "stickiness" causes the concentrate to adhere to the surfaces of the dryer.

Similarly, eggs, especially whole egg, contain a range of lipids and lipoproteins which become denatured on heating. One of the main problems caused by denaturing of egg protein is that the reconstituted egg loses the ability to be whipped into a stable foam. In addition, breakdown of the protein structure also breaks the natural emulsion and fat separates as discrete droplets. Dried egg cannot thus be reconstituted with water to produce a genuinely egg-like substance. Various additives have been proposed in order to maintain the whipping power of reconstituted egg, typically polyphosphates and surfactants. It is also been proposed to add sucrose or a dextrose source such as corn syrup or corn syrup solids (U.S. Patent 3162540). Sucrose is added at the surprisingly high level of 10% which provides an extremely sweet substance. This is acceptable if the egg is to be used in the manufacture of cakes and confectionery but would be completely unacceptable in other uses.

A further problem of degradation occurs in the production of instant coffee, where ground coffee solids are extracted at high temperatures (e.g. 120°C) with water to produce an extract having, typically, 30 to 60% solids which is then spray dried to form a powder. The protein content of the final powder is about 14%. The high temperature extraction and subsequent spray drying inevitably lead to a product which has harsh bitter

flavours as compared with fresh ground coffee extracted at below 100°C. These harsh flavours are particularly noticeable if the coffee is consumed black.

Another problem of drying involves pastes and purees of fruit and vegetable material having a characteristic cellular structure, for example tomato puree. If tomato puree is dried at elevated temperatures, the cellular structure is broken down and the product can only be reconstituted as a paste lacking the characteristic tomato texture. In addition, the drying renders the tomato solids discoloured and caramelised.

Fruit juices are also difficult to dry effectively, often losing their characteristic freshness and flavour. "Instant" dried orange juice, for example, is generally regarded as inferior to fresh or carton juice.

We have now discovered that one particular sugar can be incorporated in proteinaceous foodstuffs before they are heat treated and dried with the result that the protein is largely protected from denaturation so that the reconstituted product much more closely resembles the original. Similarly this sugar can be incorporated in fruit and vegetable purees and juices and the like, with retention of the freshness and structure of the original. In this respect, the added sugar is considerably more efficient than sucrose or glucose, without rendering the product particularly sweet.

SUBSTITUTE SHEET

According to the present invention there is provided a method of drying a water-containing foodstuff or beverage at a temperature above ambient, by incorporating trehalose into the foodstuff or beverage which is to be dried.

Trehalose, α -D-glucopyranosyl- α -D-glucopyranoside, is a naturally occurring non-reducing disaccharide which is found in some organisms, both plant and animal, which can resist being dried. These organisms include brine shrimps cysts, (*Artemia salina*), the resurrection plant (*Selaginella lepidophylla*) and baker's yeast (*Saccharomyces cerevisiae*). We have found that the addition of trehalose to proteinaceous foodstuffs enables them to be not only dried, but also heated at quite high temperatures, without significant denaturation. In general, the trehalose should be added to the foodstuff at a level giving a weight ratio of trehalose: protein of, for example, 1:2.5 to 1:15. Preferably the weight ratio should be from 1:2.5 to 1:7.5. Thus, for example, whole milk contains 3.3% protein and can be efficiently stabilized by the addition of 0.5% by weight of trehalose, a ratio of 1:6.6 by weight. Whole egg containing 12.3% protein can be stabilized by addition of 3 to 5% by weight of trehalose, a weight ratio of about 1:2.5 to 1:4. Coffee extracts can be produced containing a solids content including 1 or 2% trehalose: a approximate weight ratio of 1:7 to 1:14 based on the protein content.

In cases where the protein content is small and/or not easily measurable and/or there is a cellular structure to preserve, for example fruit purees, then the trehalose can be added at a weight ratio of trehalose:non-fat solids of 1:5 to 1:100, especially 1:5 to 1:3. These ranges are also applicable to foodstuffs such as egg and milk. In the case of 0.5% trehalose in whole milk containing 3.3% protein, the total non-fat solids content is about 8%, giving a weight ratio of trehalose:non-fat solids of 1:16. Trehalose at 3% in whole egg containing about 26% solids gives a ratio of 1:8.7. Dried coffee solids containing 1 or 2% trehalose have a ratio of 1:50 to 1:100. Juices and purees can contain from 1 to 15% by weight of trehalose.

An additional advantage of incorporating trehalose is that, surprisingly, the speed of re-hydration is much increased over controls and over samples containing sucrose.

The following Examples illustrate the invention further:

Example 1 Full Cream Milk

Fresh pasteurised whole milk was concentrated and spray dried in the presence of trehalose at 0.5% of the weight of the whole milk. From the same bulk supply of milk an untreated control sample was also processed.

Trehalose was added to the milk using simple agitation. The sample was concentrated to an industry standard of about 30% milk solids using, in this instance, a single-tube climbing film vacuum evaporator with a column temperature of from 40°C - 80°C.

The resulting concentrate was fed into a spray-drier with a chamber temperature of 175°C - 205°C. Outlet temperatures were in the region 85°C - 98°C.

The powder collected was rehydrated by the addition of sufficient cold water to achieve the status of fresh milk. It was noted that the sample containing trehalose was more easily re-wetted than the control. The trehalose sample was considered to have the organoleptic properties of fresh milk. This can be described as a "clean" lactic note. The texture was also more integrated and homogeneous. The control sample was more like the familiar reconstituted powder.

When heated, it was observed that the trehalose-containing sample had the characteristic aroma of heated fresh milk and formed a surface "skin". This is evidence of the milk proteins lactalbumin and lactoglobulin. This "skin" was not evident in the control sample indicating that these milk proteins had been denatured.

Example 2 Hens' Egg

Fresh whole hens' egg is particularly susceptible to high temperature dehydration, e.g. spray-drying. The resultant product is significantly inferior in performance and organoleptic quantities to the original raw material.

In this experiment 3% trehalose by weight was added to fresh whole hens' egg. This was achieved by whisking the egg and the trehalose to form an even blend.

The mixture was spread onto glass drying plates and dried in a warm air drying oven. Temperatures were from 45°C - 50°C. Samples of egg were prepared without trehalose and dried alongside the test samples to form controls. The samples were dried until all moisture had been removed and only egg solids remained. The final dried egg flakes were ground to produce a fine powder which was easily reconstituted.

The powders were then rehydrated with cold water to return to a theoretical natural egg solids ratio. It was noted that the sample containing trehalose went more readily into a smooth homogeneous dispersion.

The egg solutions were tested in 2 ways:-

1. Preparation of "scrambled" egg

Samples containing 50g of egg solution blended with 20g of fresh milk were placed in a 650w microwave and cooked for 2 mins on full power, the samples being stirred at 30 second intervals.

The test sample with trehalose had the aroma and texture akin to that of fresh scrambled egg. The proteins had readily coagulated producing a soft pleasing texture with a pale yellow colour. The control sample did not coagulate totally, producing a grey, rubbery texture which had an unpleasant aroma and eating quality.

2. Preparation of Yorkshire Pudding Batter

A batter was made consisting of 40g of egg solution, 40g plain flour, 100g fresh milk and 2g of salt.

The batter was poured into pre-heated tins and baked for 20 mins at 200°C together with a control batter made from the untreated dried egg.

Care was taken to ensure that the baking conditions were the same for all samples.

The finished puddings were examined for lift, volume and texture. The samples containing trehalose had an increased volume and a more even shape. The eating quality was superior to the control.

Conclusion

These results indicate that the proteins within the control sample had been substantially denatured, whereas the protein activity of the trehalose sample was much closer to that of fresh egg.

Example 3 Coffee

Roast coffee beans were finely ground, hot water and trehalose added, then the whole subjected to a temperature of 120°C, in order to effect the extraction of the soluble solids. The insoluble solids were then removed leaving a solution containing between 30 - 55% solids depending upon the efficiency of the extraction process.

The solution was spread onto glass drying plates and dried in a warm air drying oven. Temperatures were from 45°C - 50°C. Samples of coffee were prepared without trehalose and dried alongside the test samples to form controls.

Samples were prepared containing trehalose at between 0.5% and 5% by weight of the ground coffee weight, prior to extraction. Dried samples were then reconstituted to form a potable coffee solution and assessed together with the control sample. The extraction and drying methods used had produced a dark solution with very pronounced bitter notes in the control sample. The samples containing trehalose were lighter in colour and had considerably less after-taste with a lower evidence of "bitter" notes. Although trehalose performed reasonably well at 0.5%, the sample at 1% was very good and was, in fact, not significantly better than those at higher levels.

As with other experiments, the trehalose sample was much closer to the original pre-dried material in overall flavour profile than the control sample. No attempt was made in this particular test to identify the compounds responsible for the "bitter" flavours that occurred.

Example 4 Tomato

Spray-dried tomato powder is widely used in the Food Industry. It forms the basis for a number of dry-mix sachet and carton products - soups, sauces, casserole-mixes, drinks and various cooking-aid products.

The reconstituted dried material is significantly inferior to the "wet" preserved product, e.g. canned and frozen concentrates, pasteurised or aseptically processed concentrates, juice or passata.

The dried material currently available does not recover, when reconstituted, the cellular structure or colour typical of the "wet" preserved products. This can also be said of the more sophisticated and expensive product obtained by vacuum freeze-drying (lyophilisation).

In this experiment, raw frozen Italian tomato puree with a solids content (T.S.S) of 28% by weight was used.

The tomato was allowed to thaw and samples were prepared containing trehalose at levels between 1% - 5% w/weight, the trehalose being easily incorporated in dry form into the weighed sample of tomato. The puree was spread onto glass drying plates and dried in a warm air drying oven. Temperatures were from 50°C - 100°C. Samples of tomato were prepared without trehalose and dried alongside the test samples to form controls. The dried samples were reconstituted to reform to the original solids content.

The severity of the drying method used meant that the products had suffered loss of colour, most samples being dark red to black. However, the sample containing 5% trehalose had maintained colour the best. It also, when rehydrated, completely recovered the cellular or 3-dimensional molecular structure of the original material. The flavour had also been "protected" being less caramelised than the control.

The control sample when rehydrated formed a dark-red slurry with a prominent caramelised flavour. It did not resemble the raw material in any way.

Example 5 Hens' Egg (Comparative)

The relative benefits of trehalose were compared with an alternative disaccharide (sucrose) and a monosaccharide (dextrose).

Samples were prepared by taking measured amounts of blended hens' egg and addition 5% by weight of sucrose, dextrose and trehalose.

The three separate samples were spread onto glass drying plates and dried in a warm air drying oven. Temperatures were from 40°C - 50°C. Samples of egg were prepared without addition and dried alongside the test samples to form controls. The samples were dried until

25% of the original weight remained, in theory removing all moisture (fresh whole hens' egg contains 74.8% water - ref: McCance & Widdowson ed. A. A. Paul and D. A. T. Southgate. H.M.S.O. 4th Edn.).

When cool, each dried egg sample was ground into a fine powder and rehydrated with cold water to return to the original starting weight. The samples were left to hydrate for 1 minute and then whisked lightly to check for foaming ability.

The three sugar-containing samples all foamed readily on being whisked. All had a more viscous and "integrated" appearance as compared with the control with the trehalose sample performing best in this respect.

The control sample was paler in colour, had an uneven precipitated appearance and would not foam at all.

All of the samples were then tested as "scrambled" egg.

10% by weight of fresh milk was added to the samples. Each was then cooked in a microwave (650w) at half power for 90 seconds total, interrupted for stirring the sample at 30, 45, 60, 70 and 80 seconds.

The control sample did not coagulate fully, and had a very firm uneven texture with a strong "cooked egg" aroma. The flavour was typical of a "processed" egg product.

The samples containing sucrose and dextrose were both softer in texture and more even in colour. Both still had the unpleasant "cooked egg" aroma however, and were excessively "sweet" tasting. The trehalose sample had a similar soft texture and even colour. The striking difference being in the aroma and taste. The trehalose sample was spontaneously described by the tasters as having a "natural" or fresh flavour. The overall taste was light and pleasing as opposed to the harsh cooked flavour of the control, or the "cooked" aroma of the other samples.

Example 6

Orange juice concentrate containing 7.5% by weight orange solids and 15% by weight trehalose was spray dried (air inlet temperature 170°C; air outlet temperature 80-84°C; atomiser speed 40,000 rev/min). For evaluation, the dried powder was diluted 1 part to 6 parts water. The trehalose-containing samples rehydrated much more readily the control samples containing maltodextrin as carrier. They had a better appearance and flavour.

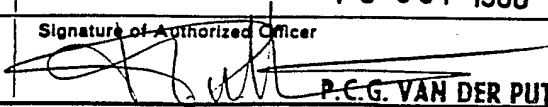
CLAIMS

1. A method of drying a water-containing foodstuff or beverage at a temperature above ambient, characterised by incorporating trehalose into the foodstuff or beverage which is to dried.
2. A method according to claim 1, wherein the foodstuff or beverage is proteinaceous and the trehalose is added at a weight ratio of trehalose:protein of 1:2.5 to 1:15.
3. A method according to claim 2, wherein the weight ratio is 1:2.5 to 1:1.75.
4. A method according to claim 1, wherein the trehalose is added at a concentration of from 0.5 to 15% by weight.
5. A method according to claim 1, wherein the foodstuff or beverage comprises milk or egg.
6. A method according to claim 1, wherein the foodstuff or beverage comprises a juice, juice concentrate, paste of puree, of fruit or vegetable.

INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 88/00511

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) *		
According to International Patent Classification (IPC) or to both National Classification and IPC IPC ⁴ : A 23 L 1/30; A 23 L 2/08; A 23 C 1/16; A 23 B 5/02		
II. FIELDS SEARCHED		
Minimum Documentation Searched ⁷		
Classification System	Classification Symbols	
IPC ⁴	A 23 L; A 23 B; A 23 C; A 23 F; A 61 K	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched *		
III. DOCUMENTS CONSIDERED TO BE RELEVANT *		
Category *	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³
X	WO, A, 86/01103 (LIPOSOME CO.) 27 February 1986, see claims 1,4,5,11,14,15; example 1	1
A	--	2-6
X	EP, A, 0211257 (ABBOTT LABORATORIES) 25 February 1987, see claims 1,4,5,6; page 2, lines 34,35; page 8, lines 11-30; example 3	1
A	--	2-6
A	US, A, 3162540 (L. KLINE et al.) 22 December 1964, see claim 1	1-6
A	US, A, 3170804 (L. KLINE et al.) 23 February 1965, see claim 1	1-6

<div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <p>* Special categories of cited documents: ¹⁰</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> </div> <div style="width: 45%;"> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"&" document member of the same patent family</p> </div> </div>		
IV. CERTIFICATION		
Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report	
28th September 1988	19 OCT 1988	
International Searching Authority	Signature of Authorized Officer	
EUROPEAN PATENT OFFICE	 P.C.G. VAN DER PUTTEN	

**ANNEX TO THE INTERNATIONAL SEARCH REPORT
ON INTERNATIONAL PATENT APPLICATION NO.**

GB 8800511

SA 23016

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 12/10/88
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO-A- 8601103	27-02-86	WO-A- 8601102	27-02-86
		EP-A- 0190315	13-08-86
		EP-A- 0191824	27-08-86
		JP-T- 62500101	16-01-87
		JP-T- 62500102	16-01-87
EP-A- 0211257	25-02-87	AU-A- 6021586	05-02-87
		JP-A- 62029513	07-02-87
US-A- 3162540		None	
US-A- 3170804		None	